

STATE OF CALIFORNIA  
AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME II

STANDARD OPERATING PROCEDURES  
FOR  
AIR QUALITY MONITORING

APPENDIX T

METEOROLOGICAL PARAMETER PROCEDURES  
FOR  
WIND SPEED SENSORS

MONITORING AND LABORATORY DIVISION

JULY 1995

## TABLE OF CONTENTS

### APPENDIX T

#### METEOROLOGICAL PARAMETER PROCEDURES FOR WIND SPEED SENSORS

	<u>PAGES</u>	<u>REVISION</u>	<u>DATE</u>
<b>T.1 - STATION OPERATOR'S PROCEDURES</b>			
T.1.0 GENERAL INFORMATION	7	0	7-28-95
T.1.0.1 Theory of Operation			
T.1.0.2 System Description			
T.1.1 INSTALLATION PROCEDURES	2	0	7-28-95
T.1.1.1 Physical Inspections			
T.1.1.2 Initial Set-Up/Installation			
T.1.2 ROUTINE SERVICE CHECKS	4	0	7-28-95
T.1.2.1 General Information			
T.1.2.2 Daily Checks			
T.1.2.3 Biweekly Checks			
T.1.2.4 Monthly Checks			
T.1.3 DETAILED MAINTENANCE PROCEDURES	1	0	7-28-95
T.1.4 TROUBLESHOOTING	1	0	7-28-95
T.1.4.1 General Information			
T.1.4.2 Troubleshooting			
<b>T.2 - ACCEPTANCE TEST PROCEDURES</b>			
T.2.0 ACCEPTANCE TEST PROCEDURES	4	0	7-28-95
T.2.0.1 General Information			
T.2.0.2 Physical Inspection			
T.2.0.3 Operational Checks			

## TABLE OF CONTENTS (cont.)

### APPENDIX T

#### METEOROLOGICAL PARAMETER PROCEDURES FOR WIND SPEED SENSORS

	<u>Pages</u>	<u>Revision</u>	<u>Date</u>
<b>T.3 - CALIBRATION PROCEDURES</b>			
T.3.0 OVERVIEW	2	0	7-28-95
T.3.0.1 Theory			
T.3.0.2 Calibration Equipment			
T.3.1 CALIBRATION PROCEDURES	8	0	7-28-95
T.3.1.1 General Information			
T.3.1.2 Starting Torque Test			
T.3.1.3 Wind Speed Accuracy Calibration			

**APPENDIX T**

**METEOROLOGICAL PARAMETER PROCEDURES**

**FOR**

**WIND SPEED SENSORS**

**FIGURES**

	<u>Page</u>
Figure T.1.0.1...Met One 010 Wind Speed Sensor.....	3
Figure T.1.0.2...R.M. Young 05305 Wind Monitor-AQ .....	4
Figure T.1.0.3...Met One 1180 Translator Module .....	5
Figure T.1.0.4...CARB Standardized Meteorological Sensor Interconnect.....	6
Figure T.1.0.5...CARB Meteorological Sensor Cable .....	7
Figure T.1.2.1...Monthly Quality Control Maintenance Checksheet .....	3
Figure T.2.0.1...Acceptance Test Log .....	3
Figure T.2.0.2...Acceptance Test "Mini" Report.....	4
Figure T.3.1.1...Wind Speed Calibration Datasheet .....	7
Figure T.3.1.2...Sample Calibration Report.....	8

STATE OF CALIFORNIA  
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AIR MONITORING QUALITY ASSURANCE

VOLUME II

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FOR  
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APPENDIX T.1

STATION OPERATOR'S PROCEDURES  
FOR  
WIND SPEED SENSORS

MONITORING AND LABORATORY DIVISION

JULY 1995

## T.1.0 GENERAL INFORMATION

### T.1.0.1 THEORY OF OPERATION

Wind speed is generally measured by common anemometers, which are either cup assemblies turning on a vertical axis or propellers turning on a vane-oriented horizontal axis. The Cup anemometer is an empirical sensor in that the relationship between the Cup's rate of rotation and the wind speed is determined by testing rather than defined by theory. The Cup assembly has an aerodynamic shape which converts the wind pressure force to torque (hence rotation) because of a symmetrical lift and drag. However, the cup is not very **efficient and creates turbulence as** the air flows through and around it. The Cup anemometer is omnidirectional to horizontal flow, but exhibits a complicated reaction to vertical components and may indicate a speed slightly greater than the total speed when the flow is non-horizontal. The propeller anemometer is a more efficient shape and creates little turbulence as the air flows mostly through it. The propeller measures wind speed when it is oriented into the wind. Its errors from imperfect alignment with some mean vector are small, being nearly proportional to the cosine of the angle of misalignment. In either of these types of anemometers, the rate of rotation is sensed by some transducer. There are many commercially available wind speed sensors. The two primary systems used by the California Air Resources Board (CARB) are manufactured by Met One Instruments and the R.M. Young Company. These Standard Operating Procedures (SOPs) will only discuss the Met One 010 Wind Speed Sensor (Figure T.1.0.1) and the R.M. Young 05305 Wind Monitor-AQ (Air Quality) (Figure T.1.0.2). However, these procedures can serve as a guide for other wind speed sensors.

### T.1.0.2 SYSTEM DESCRIPTION

1. Met One 010 Wind Speed Sensor
  - a. The Met One 010 Wind Speed Sensor uses a durable 3-cup anemometer assembly and solid-state optical link with a 40-slot chopper disc to produce a pulsed output with a frequency which is proportional to wind speed. An internal heater maintains the sensor interior at a positive pressure, which provides positive aspiration through the bearings and contributes to extended bearing life. This sensor is usually used in conjunction with the Met One 184 Crossarm Assembly, the Met One A1153-XX Sensor Cable (XX is cable length in feet), and the Met One 1180 translator Module (Figure T.1.0.3).

**NOTE:** The A1153-XX sensor cables can be retrofitted with a CARB standardized meteorological sensor interconnect and cable (Figures T.1.0.4 and T.1.0.5).

- b. The Met One 1180 Translator Module converts the frequency signal from the wind speed sensor into a standardized voltage/current output signal. In typical use, the translator module provides +12 volt direct current (YDC) for sensor power. There are built-in zero and full-scale test switches and input and output test points in the front of the translator module. Also located on the front panel is a three-position range switch which selects the full-scale velocity. Two analog output signals are available from the output of the translator module.

2. R.M. Young 05305 Wind Monitor-AQ

- a. The R.M. Young 05305 Wind Monitor-AQ measures horizontal wind speed and direction. The main housing, nose cone, propeller, and other internal parts are constructed of injection molded ultraviolet stabilized plastic. The tail section is constructed of thermoformed expanded polystyrene. The nose cone assembly threads directly into the main housing, contacting an o-ring seal. Both the propeller and vertical shafts use stainless steel precision grade ball bearings. The propeller shaft bearings have shields to help exclude contamination and moisture.
- b. The propeller rotation produces an alternating current (AC) sine wave signal with a frequency proportional to wind speed. This AC signal is induced in a stationary coil by a six-pole magnet mounted on the propeller shaft. Three complete sine wave cycles are produced for each propeller revolution.

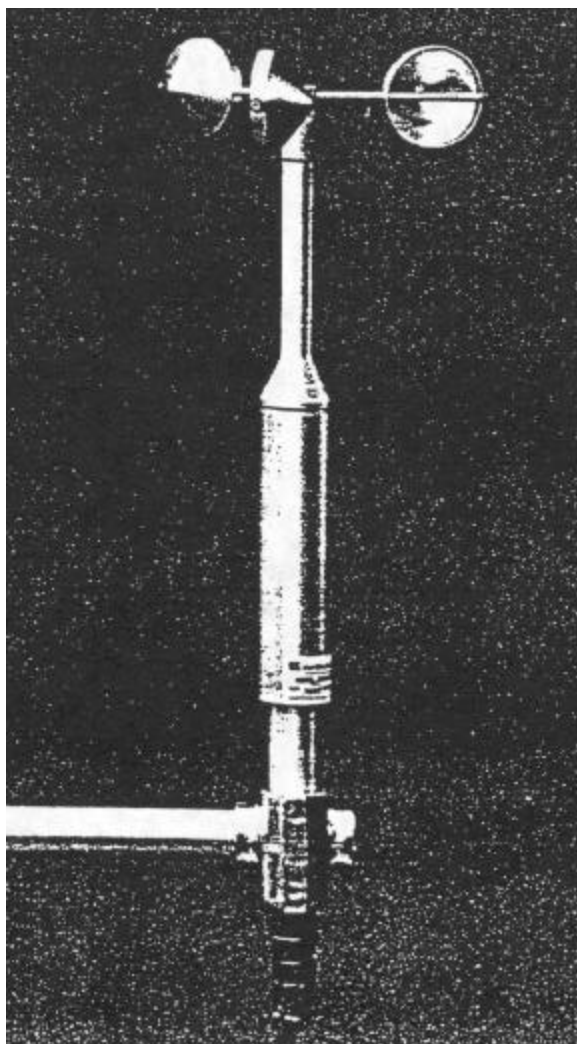


Figure T.1.0.1  
Met One 010 Wind Speed Sensor



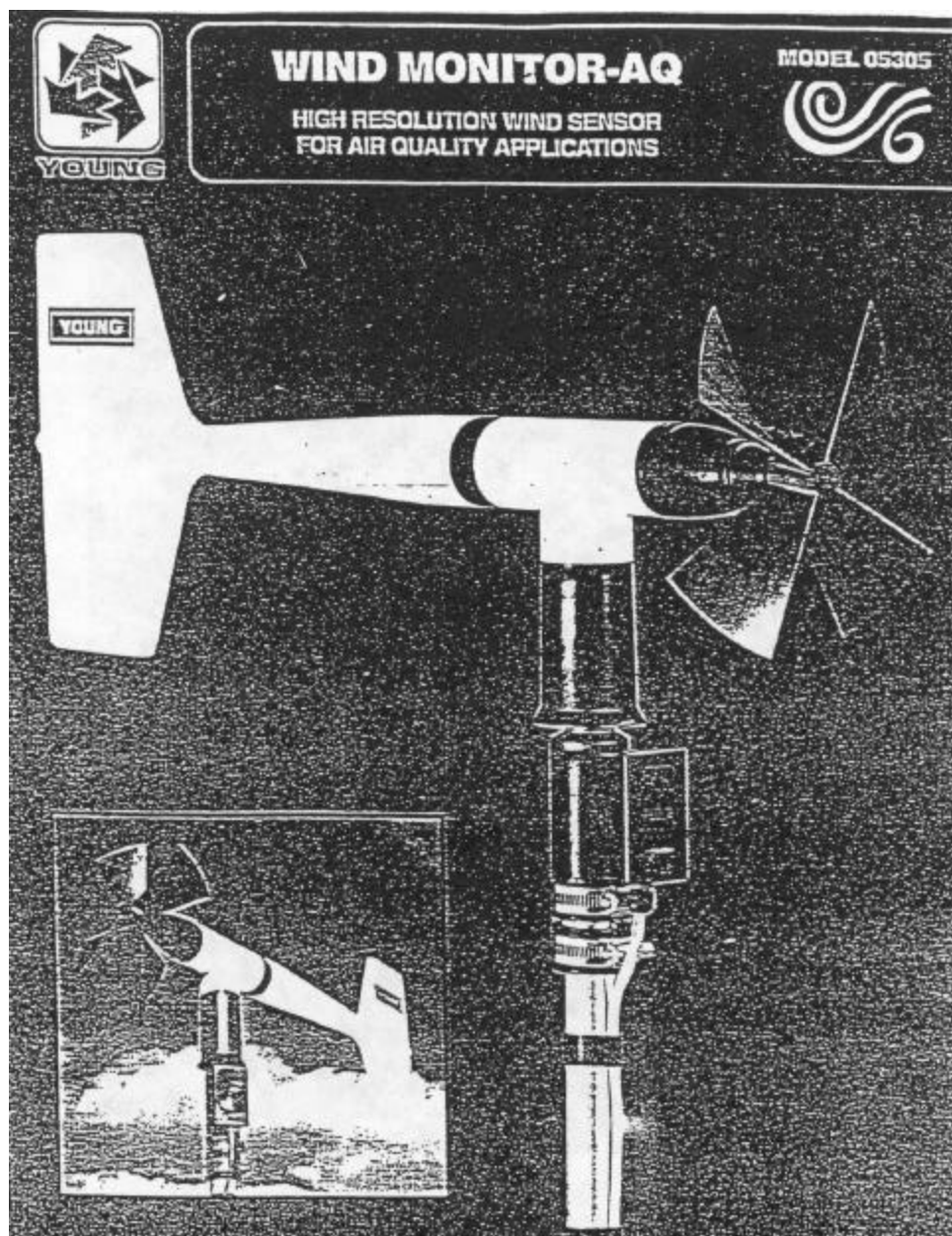


Figure T.1.0.2  
R.M. Young 05305 Wind Monitor-AQ



Met One 1180 Translator Module

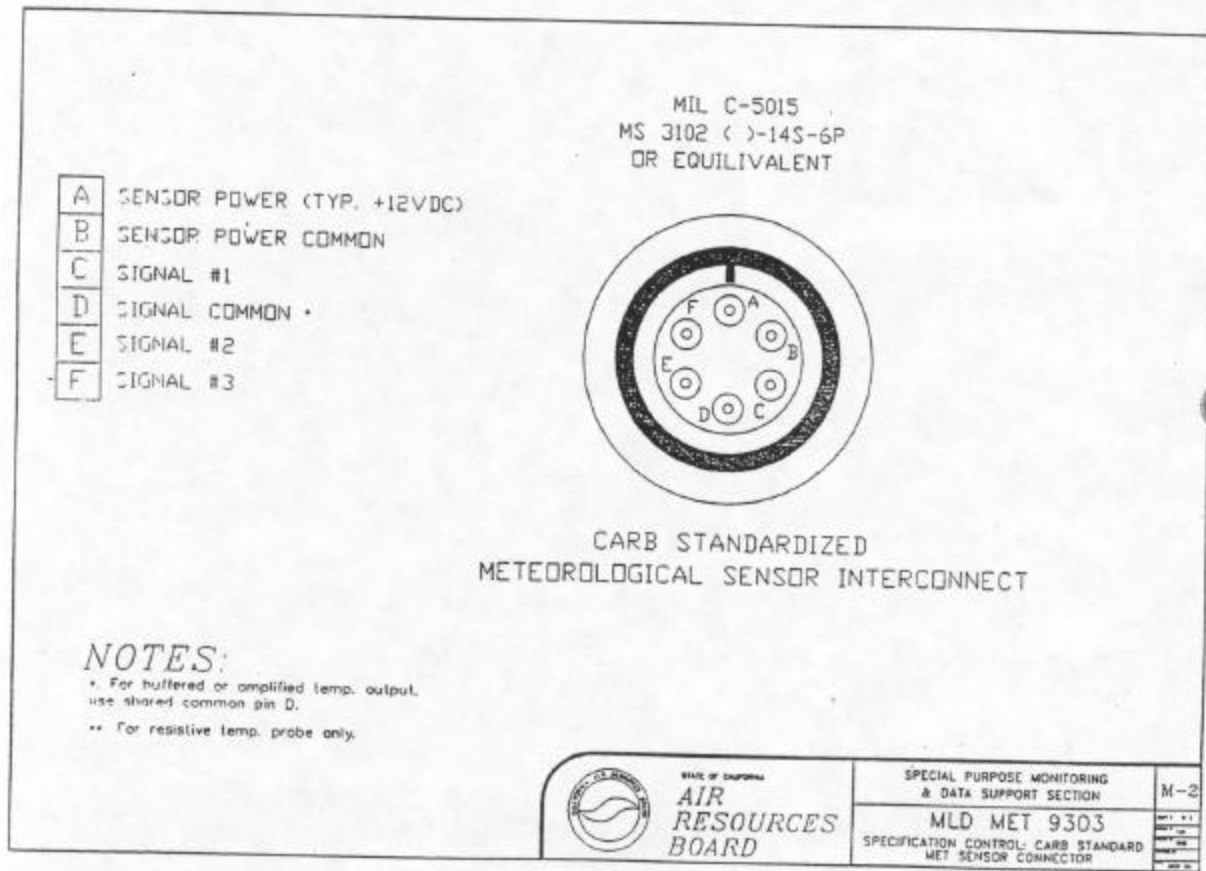


Figure T.1.0.4  
CARB Standardized Meteorological Sensor Interconnect

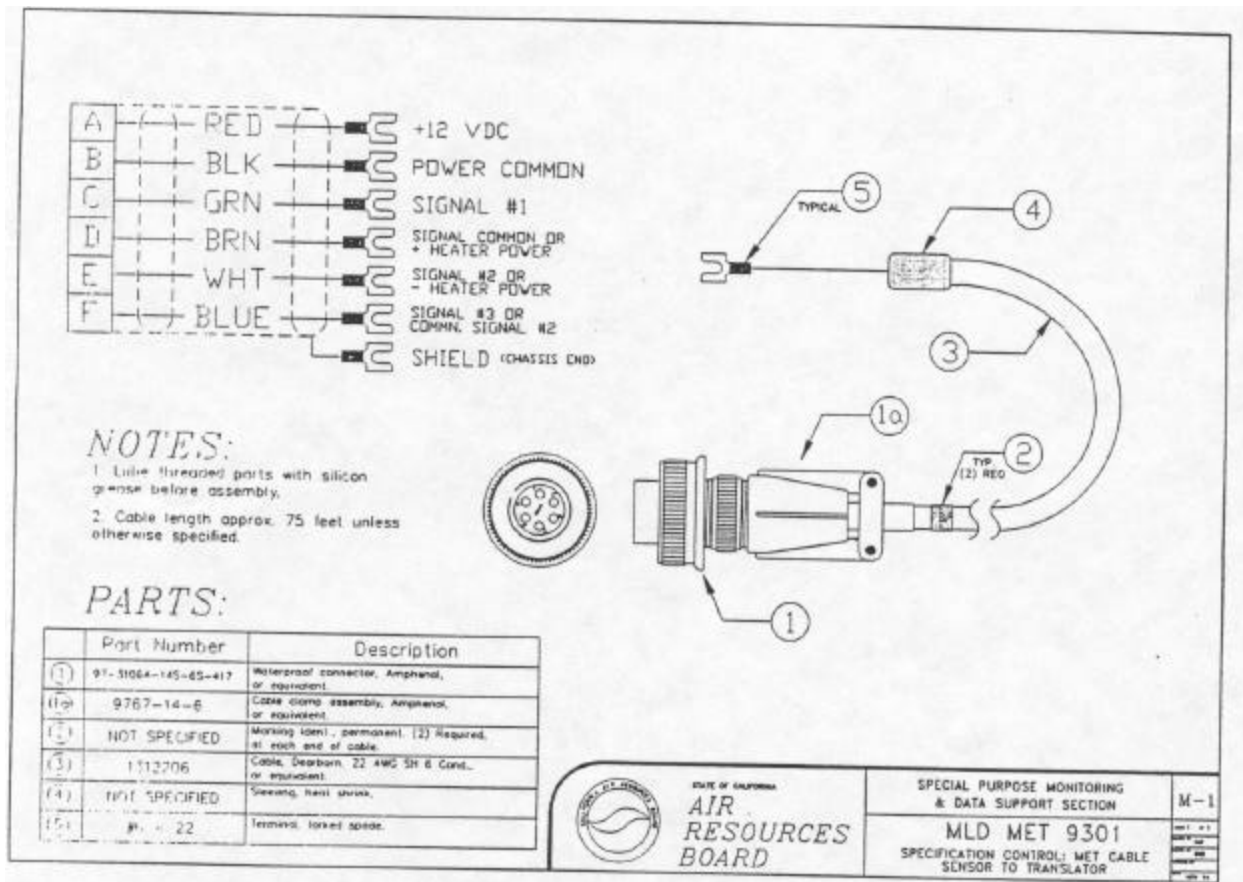


Figure T.1.0.5  
CARB Meteorological Sensor Cable

## **T.1.1        INSTALLATION PROCEDURES**

### **T.1.1.1     PHYSICAL INSPECTIONS**

Upon receiving the wind speed systems, unpack and check for any signs of shipping damage.

### **T.1.1.2     INITIAL SET-UP/INSTALLATION**

Proper operation of any meteorological sensor is directly related to the siting of the sensor. An ideal installation is one where the operator can safely access the sensor, perform a test adjacent to the **electronics and recorder**, and re-install the sensor. Station operators should read the CARB Air Monitoring Quality Assurance Standard Operating Procedures for Air Quality Monitoring, Volume II, Section 2.0.8 (Siting Requirements for Meteorological Equipment); the United States Environmental Protection Agency (U.S. EPA), Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV; and U.S. EPA Prevention of Significant Deterioration (PSD) guidelines to get a more detailed description of siting requirements. The CARB Air Monitoring Quality Assurance Standard Operating Procedures for Air Quality Monitoring, Volume II, will be referred to as the CARB SOP for Air Quality Monitoring, Volume I, for the rest of this document.

**NOTE:**        To obtain specific information regarding the installation of wind speed sensors, read the sensor operating manual. Also, best results are achieved if two people perform the installation. Be sure to have silicon grease, electrical tape, and Ultra Violet stabilized zip ties with you.

#### **1.        Met One 010 Wind Speed Sensor Installation**

- a.        Carefully mount the cup assembly onto the sensor by supporting the rotation hub with one hand while fitting the cup assembly onto the hub with the other hand. The cup assembly is keyed to fit the hub. A properly seated cup assembly will mount "flush" against the hub.
- b.        Spin the cup assembly to verify that it rotates freely.
- c.        Install the sensor in the end of the Met One 184 Mounting Arm (the end without the keyed bushing). Apply a small amount of silicon grease to the stem of the sensor.

- d. Tighten the locking set screw. DO NOT over-tighten. Apply a small amount of silicon grease to the set screw to prevent freezing in corrosive environments.
- e. Connect the Met One A1153-XX cable to the keyed sensor receptacle and tape it to the mounting arm.
- f. Connect the leads of the Met One A1153-XX cable to the appropriate points on the Met One 1180 translator module (Figure T.1.0.3 and T.1.0.4).

2. R.M. Young 05305 Wind Monitor-AQ Installation

- a. Place the orientation pointer on the mounting post.
- b. Assure that enough space is left above the pointer so that the sensor is firmly mounted and seats on the orientation pointer clamp.
- c. Align the orientation pointer to True North using a compass. The compass should be mounted on a non-magnetic tripod when performing this alignment. Refer to CARB SOP for Air Quality Monitoring, Volume II, Section V.1.1.3 on the alignment procedure (Wind Direction Sensor Alignment) for specific instructions.
- d. Connect the CARB meteorological sensor cable or the R.M. Young cable to the junction box on the R.M. Young wind speed sensor base. Tape the cable to the tower.
- e. Connect the leads of the cable to the appropriate points on the R.M. Young translator module.

## **T.1.2 ROUTINE SERVICE CHECKS**

### **T.1.2.1 GENERAL INFORMATION**

Perform the following checks on wind speed sensors at the intervals specified in the service schedule. The checks may be performed more frequently, but should be performed at least at the prescribed intervals. Document all results and maintenance on the Monthly Quality Control Maintenance Checksheet (Figure T.1.2.1).

### **T.1.2.2 DAILY CHECKS\***

1. Review datalogger and strip chart data for correct operation of the wind speed sensor.
2. Data editing for wind speed data must be in accordance with the CARB SOP for Air Quality Monitoring, Volume II, Section 2.0.2.8 (Specific Criteria for Data Validity).
3. Perform a visual inspection of the wind speed sensor to ensure that the propeller or cup is turning and is not damaged.

\* **or each day** the operator services the station

### **T.1.2.3 BIWEEKLY CHECKS**

1. Perform a visual inspection of the wind speed sensor to ensure that the propeller or cup is turning and is not damaged.
2. Review the data. Check for excess zero and span drifts, noncharacteristic data, or blank spaces on the Data Summary Reports.
3. Record the datalogger outputs on the Monthly Quality Control Maintenance Checksheet (Figure T.1.2.1). Instantaneous wind speed readings will fluctuate on the datalogger, so station operators should watch the readings for approximately 15 to 20 seconds and estimate the average. After some experience is gained with properly making a visual estimate of wind speed, the estimated datalogger average should be within  $\pm 5$  knots of a visual estimate of the wind speed. For example, note if the winds are blowing heavily and the

propeller or cup is turning slowly and the datalogger is reading an unreasonably low wind speed.

4. Perform the zero and full scale checks on the Met One 1180 translator module (Met One only).

#### T.1.2.4 MONTHLY CHECKS

Complete and submit the Monthly Quality Control Maintenance Checksheet (Figure T.1.2.1) to your supervisor.



CALIFORNIA AIR RESOURCES BOARD MONTHLY QUALITY CONTROL MAINTENANCE CHECK SHEET METEOROLOGICAL INSTRUMENTATION									
Location: <u>Sacramento</u>					Month/Year: <u>Aug 94</u>				
Station Number: <u>12-345</u>					Technician: <u>R. Smith</u>				

RESULTANT WIND SPEED					RESULTANT WIND DIRECTION					
DATE	TRANSLATOR CHECK (Knots)		DATALOGGER		DATE	TRANSLATOR CHECK (Deg.)		DATA-LOGGER		VISUAL CHECK
	Zero	Full	Knots	Volts		Zero	Half	Deg.	Volts	
8/3	0.006	86.84	4.2	.0484	0.00	179.9	264.2	.734	W	
8/20	0.006	86.84	8.7	.1002	0.00	179.9	210.3	.675	SW	

OUTSIDE TEMPERATURE					INSIDE TEMPERATURE					
DATE	REF	TRANSLATOR CHECK (C)		CHART	DATALOGGER	REF	CHART	DATALOGGER		
	°C	Zero	Full	°C					°C	°C
8/3	22.7	-50.00	50.00	22	22.48	.738	24	24	24.1	.487
8/20	19.4	-50.00	50.00	19	19.7	.699	25	25	25.3	.503

PERCENT RELATIVE HUMIDITY							NO SOL RAD at Site			
DATE	TRANSLATOR CHECK (%RH)		CHART %RH	REFERENCE RH SENSOR		DATALOGGER	SOLAR RADIATION			
	Zero	Full		%RH	%RH		%RH	Volts	TRANSLATOR CHECK (W/m2)	DATALOGGER
8/3	0.0	100.1	37	34.3	37.4	.374	<div style="border: 1px solid black; width: 100%; height: 100%; position: relative;"> <span style="position: absolute; top: -20px; left: 50%; transform: translateX(-50%);">NO SOL RAD at Site</span> </div>			
8/20	0.0	100.1	43	45.7	43.7	.457				

Figure T.1.2.1  
Monthly Quality Control Maintenance Checksheet

OPERATOR INSTRUCTIONS:

1. Daily Checks: Review datalogger and strip charts.
2. Bi-Weekly Checks: Record datalogger and strip chart readings.  
Record translator check readings (MET ONE ONLY).  
RWS: Visually inspect sensor cups or propeller for damage.  
RWD: Visually inspect wind vane for damage and record estimated wind direction  
(N, SW, NE, etc).  
RH: Check station sensor versus reference %RH sensor.  
OTEMP/RH: Radiation shield fan operating.  
SOL. RAD: Radiation sensor not shaded.
3. Monthly Checks: Complete monthly maintenance Checksheet.  
SOL. RAD: Clean radiation sensor element.
4. Semi-Annual Checks: Calibration (Last Cal. Date: July 1994 )
5. As needed checks: Inspect and lubricate sensor cable connections with silicon-based grease.  
Clean radiation shield housing.

Note: Resultant Wind Speed (RWS) and Resultant Wind Direction (RWD) datalogger readings will fluctuate, so operator should watch output for 15 – 20 seconds and record the average reading in the space provided. This value should be approximately  $\pm 5$  knots (RWS) and  $\pm 30$  degree (RWD) of visual estimates.

Generally, %RH exceeds 70% during the nighttime and early morning hours, considering that the instruments are generally most accurate between 20% and 80% of their range. QC checks should be made sometime during the day when %RH sensor and the reference RH sensor (GT-L Hygroskop or Pyschro-dyne) is greater than 10% RH; a problem may exist and the operator should troubleshoot to correct the problem. Station sensor filter cover may be excessively dirty.

Date	COMMENTS OR MAINTENANCE PERFORMED
8 / 3	<i>Cleaned radiation shield</i>

MLD-111 2 of 2 (9/94)

Reviewed by: \_\_\_\_\_ Date: \_\_\_\_\_

Figure T.1.2.1 (cont.)  
Monthly Quality Control Maintenance Checksheet

### **T.1.3 DETAILED MAINTENANCE PROCEDURES**

The Met One 010 Wind Speed Sensor and R.M. Young 05305 Wind Monitor-AQ are designed to provide years of service. They are constructed of noncorrosive materials and require little maintenance. The only components likely to need replacement due to normal wear are the precision bearings. General maintenance requirements are provided below. Refer to the sensor operating manual for detailed instructions on maintenance procedures.

**NOTE:** Persistent low wind speed measurements may be a sign of bad bearings. Replacement of the bearings may be necessary.

1. Inspect and lubricate the sensor cable connections with a silicon-based grease as necessary.
2. Record any maintenance, malfunctions, repairs, and actions taken to prevent recurrence of malfunction on the Monthly Quality Control Maintenance Checksheet.

## **T.1.4 TROUBLESHOOTING**

### **T.1.4.1 GENERAL INFORMATION**

Before starting any troubleshooting procedure, refer to the sensor operating manual for specific information pertaining to troubleshooting. Record malfunctions, repairs, and actions taken to prevent recurrence of any malfunction on the Monthly Quality Control Maintenance Checksheet (Figure T.1.2.1).

### **T.1.4.2 TROUBLESHOOTING**

Troubleshooting should attempt to isolate the source of the malfunction and reduce maintenance time. The following items should be checked if a problem exists:

1. Visually inspect the wind speed sensor.
  - a. Check for signs of damage.
  - b. Verify that the cup or propeller is turning freely.
2. Check for loss of voltage supply.
3. Check for proper operation of the sensor bearings. Bad bearings may affect starting threshold.
4. Verify that the cable connections are secure.
5. Measure the outputs from the wind speed sensor and/or translator using the voltmeter.
6. Verify proper datalogger initialization.

STATE OF CALIFORNIA  
AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME II

STANDARD OPERATING PROCEDURES  
FOR  
AIR QUALITY MONITORING

APPENDIX T.2

ACCEPTANCE TEST PROCEDURES  
FOR  
WIND SPEED SENSORS

MONITORING AND LABORATORY DIVISION

JULY 1995

## **T.2.0 ACCEPTANCE TEST PROCEDURES**

### **T.2.0.1 GENERAL INFORMATION**

Before beginning acceptance testing of the wind speed system, read **the sensor operating manual thoroughly**. Initiate an Acceptance Test Log (Figure T.2.0.1) and an Acceptance Test "Mini" Report (Figure T.2.0.2). **Record the dates of the individual** tests, problems, and contacts with the manufacturer, and any other pertinent information on the Acceptance Test Log.

### **T.2.0.2 PHYSICAL INSPECTION**

Unpack the wind speed system and check for physical damage. Verify that the system is complete and includes all options and parts required by the purchase order.

### **T.2.0.3 OPERATIONAL CHECKS**

Operational checks should assure that the wind speed sensors meet or exceed performance specifications stated by the vendor. Verify that the wind speed sensors meet Prevention of Significant Deterioration (PSD) guidelines for wind speed: **STARTING THRESHOLD  $\leq 0.5$  meters/second and ACCURACY  $\leq 0.2$  meters/second (0.6 miles per hour) plus 5 percent of reference**. Perform the following operational checks using a voltmeter, oscilloscope, and/or datalogger, and record the results on the Acceptance Test "Mini" Report. Tests must be run in the range normally used in field operations.

1. Translator Test - Connect a recorder or voltmeter to the output of the translator. In accordance with the sensor operating manual, verify that the translator correctly converts voltage to miles per hour or knots. Verify proper operation of the zero and full/half scale switches (Met One Only).
2. Linearity - Verify that the translator voltage outputs are linear  $\pm 5$  percent across the full scale at a minimum of five points. Enter the results on the Acceptance Test "Mini" Report linearity chart.
3. Starting Threshold Speed (Torque) Test - In accordance with the sensor operating manual, determine the starting threshold speed in meters/second (m/s). Use the formula below to calculate torque or starting threshold speed.

Torque:  $T=K*(U^2)$

Where:

T=Torque

U=Starting Threshold Speed (m/s)

K=Constant for Aerodynamic Shape

Refer to the sensor operating manual or contact the manufacturer for the "K" value. The wind speed (U) at starting threshold should be less than 0.5 meters/second (m/s) to meet PSD guidelines.

4. Range Test – Verify that the wind speed system operates over the full scale as stated in the vendors specifications.
5. Accuracy – Verify that the wind speed system accuracy meets or exceeds the vendors specification.

Make \_\_\_\_\_ Model \_\_\_\_\_ Serial \_\_\_\_\_

ACCEPTANCE TEST LOG

DATE	ACTION

Figure T.2.0.1  
Acceptance Test Log



### ACCEPTANCE TEST "MINI" REPORT

Make \_\_\_\_\_ Model \_\_\_\_\_ Date \_\_\_\_\_  
Serial \_\_\_\_\_ CARB # \_\_\_\_\_ By \_\_\_\_\_

	Pass	Fail	Comments
I. Physical Inspection			
A. Shipping damage			
B. Electrical wiring			
C. Completeness			
II. Operational Test			
A. Translator			
B. Linearity			
C. Starting Threshold			
D. Range			
E. Accuracy			
III. Special Test			
IV. Maintenance Performed			

LINEARITY                      FULL SCALE \_\_\_\_\_

%FS	True Voltage	Indicated Voltage	Diff. True-Ind	Remarks
0.00				
0.25				
0.50				
0.75				
1.00				

Absolute Value Avg. Difference \_\_\_\_\_

Abs. Value Average Difference must be less than 5% Full Scale (0.05 V)

Linear Regression      Slope \_\_\_\_\_ Intercept \_\_\_\_\_ Correlation \_\_\_\_\_

Figure T.2.0.2  
Acceptance Test "Mini" Report

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VOLUME II

STANDARD OPERATING PROCEDURES  
FOR  
AIR QUALITY MONITORING

APPENDIX T.3

CALIBRATION PROCEDURES  
FOR  
WIND SPEED SENSORS

MONITORING AND LABORATORY DIVISION

JULY 1995

## **T.3.0 OVERVIEW**

### **T.3.0.1 THEORY**

Wind speed sensors should be calibrated once every six (6) months, or more frequently in corrosive environments. Calibrations are performed to assure that a sensor's starting threshold speed is still within PSD guidelines and that the transducer is properly converting the cup or propeller rate of rotation to wind speed.

Wind speed calibrations should consist of orientation and performance checks. Orientation checks assure that the sensor is perpendicular with respect to mount. Performance checks test for errors within the sensor. Performance checks consist of a starting torque test as well as a wind speed accuracy test, with respect to a known standard.

Normally, sensors are only removed from the mast when they are undergoing maintenance and repairs or being calibrated. Therefore, sensors should be found in the same condition as when they were last placed on the mast. Before beginning the calibration, document the "AS-IS" condition of the sensor in the comments section of the Wind Speed Calibration Datasheet (Figure T.3.1.1). This will provide information to verify the validity of data between calibration periods. An "AS-IS" Wind Speed Calibration Datasheet is completed when an "AS-IS" calibration is performed. If a repair is made or the sensor is changed, a "Final" calibration form would also be completed.

### **T.3.0.2 CALIBRATION EQUIPMENT**

1. Met One 010 Wind Sensor
  - a. R.M. Young 18810 Anemometer Drive Control Unit with R.M. Young 26632 alternating current (AC) Adapter
  - b. R.M. Young 18810 Anemometer Drive Motor (10 to 1,000 rpm) with sensor interconnect
  - c. R.M. Young 18850 Clamp and Bar Assembly
  - d. CARB Retaining Collar

- e. CARB Coupling Adapter for connecting the Drive Motor to the Met One Sensor Hub
  - f. R.M. Young 18310 Cup-Wheel Torque Disc with Slotted Center with 1.0 and 0.1 gram screws
  - g. Wind Speed Calibration Datasheet (Figure T.3.1.1)
2. R.M. Young 05305 Wind Monitor-AQ
- a. R.M. Young 18801 Anemometer Drive Control Unit with R.M. Young 26632 alternating current (AC) Adapter
  - b. R.M. Young 18801 Anemometer Drive Motor (100 to 10,000 rpm) with Sensor Coupling
  - c. R.M. Young 18850 Clamp and Bar Assembly
  - d. R.M. Young 18310 Propeller Torque Disc with 1.0 and 0.1 gram screws
  - e. Wind Speed Calibration Datasheet (Figure T.3.1.1)

## **T.3.1 CALIBRATION PROCEDURES**

### **T.3.1.1 GENERAL INFORMATION**

The wind direction calibration must be completed before starting the wind speed calibration. During the wind speed calibration, look for problems which could effect the operation of the sensor such as: dirty components, and loose, worn, or broken parts. Document any noted problems on the Wind Speed Calibration Datasheet (Figure T.3.1.1). If a sensor should fail any section of the following calibrations, complete the other calibration procedures if possible.

### **T.3.1.2 STARTING TORQUE TEST**

The starting threshold speed of the wind speed sensor is influenced by the design of the cup or propeller. Wind speed sensors should have a starting threshold speed of less than 0.5 meters/second. The sensors were originally built to meet this specification. If the maximum torque in gram-centimeters (gm-cm) listed in each sensor's appropriate section is exceeded, the sensor should be replaced.

**NOTE:** The wind speed channel should be disabled. Set the data logger to "REPEAT READ" the wind speed channel. The sensor should be removed from the tower to perform the torque test.

1. Met One 010 Wind Sensor
  - a. Remove the cup assembly and attach the modified R.M. Young 18312 cup-wheel torque disc with slotted center. Place the sensor in a horizontal position (the edge of a table will work), so that it is parallel with the floor.
  - b. There are two types of weights provided with the disc, black nylon screws (0.1 gram), and stainless steel screws (1.0 gram). The screws can be combined at different radii to provide a total torque.
  - c. Orient the disc such that the holes for the screws are parallel to the floor. There are a total of 10 holes on the disc; only 5 holes on one side are used for the torque test. Screw in a 0.1 gram weight in the third hole from the center. This equals 0.3 grams-centimeters (gm-cm), which is the minimum force required to move a new sensor hub. If the disc does not turn, move the weight to the fourth hole on the disc.

- d. Turn the disc to at least four additional starting points on the hub shaft. The disc should turn at all new starting points. If not, add additional weight and retry at the four starting points. Verify if the bearings are good for the complete 360 degrees of motion in both the clockwise (CW) and counterclockwise (CCW) directions.
  - e. Record the highest torque required to turn the hub on the Wind Speed Calibration Datasheet. If the torque exceeds 0.4 gm-cm at any starting point, replace the sensor. Perform the wind speed accuracy calibration prior to replacing the sensor.
  - f. If the sensor is replaced, repeat steps a through e.
  - g. Once the starting torque test has been completed, proceed to Section T.3.1.3 on Wind Speed Accuracy Calibration.
2. R.M. Young 05305 Wind Monitor-AQ
- a. Remove the propeller and attach the 18310 torque disc in its place. Make sure that the center fits the shaft properly without excess slippage.
  - b. There are two types of weights provided with the disc: black nylon screws (0.1 gram) and stainless steel screws (1.0 gram). The screws can be combined at different radii to provide a total torque.
  - c. Orient the disc such that the holes for the screws are parallel to the floor. There are a total of 10 holes on the disc; only 5 holes on one side are used for the torque test. Screw in a 0.1 gram weight in the third hole from the center on the side, which will turn the hub in a counterclockwise direction when facing the nose of the hub. This will equal 0.3 gram-centimeters (gm-cm), which is the minimum required to move a new sensor hub. If the disc does not turn, move the weight to the fourth hole on the disc. Continue moving the weight out from the center until the disc starts to turn slightly. The torque can be increased by adding additional weights at different radii.
  - d. Turn the disc to at least four additional starting points on the hub shaft. The disc should turn at all new starting points. If not, add additional weight and retry at the four starting points. This will verify the bearings are good for the complete 360 degrees motion.

- e. Record the highest torque required to turn the hub on the Wind Speed Calibration Datasheet. If the torque exceeds 1.0 gm-cm at any starting point, replace the sensor. Perform the wind speed accuracy calibration prior to replacing the sensor.
- f. If the sensor is replaced, repeat steps a through e.
- g. Once the starting torque test has been completed, proceed to Section T.3.1.3 on Wind Speed Accuracy Calibration.

### T.3.1.3 WIND SPEED ACCURACY CALIBRATION

The wind speed accuracy calibration is performed to determine if the sensor output is correct at a minimum of five known revolutions per minute (RPM's). The datalogger should be programmed with the correct slope and intercept values, to offset any internal system errors.

#### 1. Met One 010 Wind Speed Sensor

- a. Met One cups can rotate in either the clockwise (CW) or counterclockwise (CCW) direction. Thus, all checks for accuracy of wind speed can be performed with the 18810 anemometer drive control unit (drive control unit) CW/CCW switch in either position. The formula for converting rate of rotation in RPM's to wind speed is:

$$\text{Knots} = [(\text{RPM}/16.767) + 0.6] * .8684$$

Do not allow the sensor to continue running at any one RPM setting for longer than 5 minutes. If the 5 RPM runs total up to more than 20 minutes, shut the drive control unit off for at least 5 minutes. This will allow the sensor and the drive motor to cool off and avoid any unnecessary wear.

- b. Verify that the data logger is set to "REPEAT READ" and that the wind speed sensor is connected to the sensor cable. Record the datalogger reading at 0 RPM on the Wind Speed Calibration Datasheet. The reading should be less than 0.50 knots. If it's not, verify the initialization of the data logger or the operation of the 1180 translator module.
- c. Assemble the test set-up using the R.M. Young 18850 clamp and bar assembly, CARB retaining collar, R.M. Young 18810 anemometer drive control unit, and R.M. Young 18810 anemometer drive motor.

The R.M. Young 18810 anemometer drive unit will be referred to as the "drive control unit" and the R.M. Young 18810 anemometer drive motor will be referred to as the "drive motor" throughout the rest of this Section.

- d. If possible, you should connect the AC power adapter to operate the drive control unit. The internal batteries have a difficult time maintaining the higher speeds, especially in cold weather.
- e. The drive motor contains a 10:1 gear reducer. The drive control unit display will be scaled down to a range of 10 to 1000 RPM. Adjust the RPM digits on the drive control unit to read 10. Turn the drive control unit on and allow the display to read  $1000 \pm 0002$ , which corresponds to 100 RPM because of the gear reducer. If the display does not read between 0998 and 1002, check the drive control unit coupling adapter or sensor interconnect for binding. If binding is occurring, straighten the alignment between the drive motor and the coupling adaptor or sensor interconnect. Once the display on the drive control unit is reading correctly, record the datalogger reading on the Wind Speed Calibration Datasheet. The datalogger reading should be within 5 percent of 5.70 knots.
- f. Adjust the RPM digits on the drive control unit to read 40. The drive control unit display should read  $4000 \pm 0002$  (400 RPM). Once the drive control unit display is reading correctly, record the data logger reading on the Wind Speed Calibration Datasheet. It should be within 5 percent of 21.24 knots.
- g. Repeat step e for RPM digit readings of 70 and 00. The display readings will equal 7000 (700 RPM) and 0000 (1000 RPM) on the drive control unit, and 36.77 and 52.31 knots on the datalogger, respectively.
- h. If any of the datalogger readings are off by more than five percent of the simulated wind speed in knots, the wind speed translator printed circuit board and/or the sensor will have to be repaired. This repair is done by the CARB's Air Quality Monitoring – North and Operations Support Section.
- i. If any equipment is repaired or replaced, repeat steps c through g. Return the board or sensor you just removed to the CARB's Air Quality Monitoring-North Operations and Support Section.



- j. Remove the R.M. Young 18850 clamp and bar assembly, CARB retaining collar, drive motor unit, and the CARB coupling adapter from the sensor. Disconnect the AC adapter from the drive control unit. Refer to the reinstallation procedures in the sensor operating manual or CARB SOP for Air Quality Monitoring, Volume II, Section T.1.1.2.

2. R.M. Young 05305 Wind Monitor-AQ

- a. The R.M. Young propeller rotates in a counterclockwise (CCW) direction when looking at the nose of the sensor. Thus, all checks on accuracy of speed will be performed with the 18801 drive control unit CQ/CCQ switch in the CCW position. The formula for converting rate of shaft rotation in RPM to wind speed is:

$$\text{Knots} = 0.00952 \times \text{RPM}$$

Do not allow the drive control unit to continue running at one RPM setting for longer than 5 minutes. If the 5 RPM runs total up to more than 20 minutes, shut the drive control unit off for at least 5 minutes. This will allow the sensor and drive motor to cool off and avoid any unnecessary wear.

- b. Connect the sensor coupling to the wind speed sensor. Record the datalogger reading at 0 RPM on the Wind Speed Calibration Datasheet. The reading should be less than 0.50 knots. If it's not, verify the initialization of the datalogger or the operation of the R.M. Young 9509 Translator.
- c. Assemble the calibration set-up using the R M. Young 18801 anemometer drive control unit, R.M. Young 18850 clamp and bar assembly, the R.M. Young 18801 anemometer drive motor, and the sensor coupling. The R.M. Young 18801 anemometer drive control unit will be referred to as the "drive control unit", and the R.M. Young 18801 anemometer drive motor will be referred to as the "drive motor" throughout this Section.
- d. Connect the drive motor to the drive control unit. If possible, you should connect the AC power adapter to operate the drive control unit. The internal batteries have a difficult time maintaining the higher speeds, especially in colder weather.

- e. Adjust the RPM digits on the drive control unit to read OS. Allow the drive control unit display to settle. The drive control unit display should read  $0500 \pm 0002$ . If the display does not read between 0498 and 0502, check the connection between the drive motor and the sensor coupling for binding. If binding is occurring, straighten the alignment between the drive motor and the sensor coupling. Once the display is reading correctly, record the datalogger reading on the Wind Speed Calibration Datasheet. The datalogger reading should be within 5 percent of 4.76 knots.
  - f. Repeat step e for RPM digit readings of 20, 40, 60, and 90. The display readings will equal 2000, 4000, 6000, and  $9000 \pm 0002$  RPM's on the drive control unit display, and 19.04, 38.08, 57.12, and 85.68 knots on the datalogger, respectively.
  - g. If any of the dataTogger readings are off by more than five percent of the simulated speed, the printed wind speed translator circuit board and/or the sensor will have to be repaired. This repair is done by the CARB's Air Quality Monitoring-North and Operations Support Section.
- NOTE: The R.M. Young 9509 translator is matched to the sensor. If either the sensor or the translator is replaced, both assemblies must be replaced.
- h. If any equipment is repaired or replaced, repeat steps c through f. Return the board or sensor you just removed to the CARB's Air Quality Monitoring-North and Operations Support Section.
  - i. Remove the R.M. Young 18850 clamp and bar assembly, R.M. Young 18801 drive motor, and the sensor coupling. Disconnect the AC adapter from the drive control unit. Refer to the sensor reinstallation procedures in CARB SOP for Air Quality Monitoring, Volume II, Section T.1.1.2, or the sensor operating manual.

CALIFORNIA AIR RESOURCES BOARD  
WIND SPEED CALIBRATION DATASHEET

DATE \_\_\_\_\_ CALIBRATION: AS IS ☐ ☐

SITE: Name \_\_\_\_\_ Number \_\_\_\_\_ Last Cal. Date \_\_\_\_\_

INSTRUMENT DESCRIPTION

Manufacturer \_\_\_\_\_ Model \_\_\_\_\_ Serial \_\_\_\_\_

Reporting Units \_\_\_\_\_ Range \_\_\_\_\_ Sensor Height \_\_\_\_\_

CALIBRATION EQUIPMENT:

Torque Disc Serial \_\_\_\_\_ Selectable Drive Motor Serial \_\_\_\_\_

CALIBRATION:

Starting Torque (gm-cms) \_\_\_\_\_ (Met One  $\leq 0.4$  and R.M. Young  $\leq 1.0$ )

Speed Accuracy: Met One (Difference TRUE – ESC  $< 0.4$  kts + 5% TRUE)

RPM	TRUE	ESC	Difference	
	Knots	Knots	TRUE – ESC	0 – 86.84 Kts = 0 – 1 Volt
0	0.0			
100	5.70			Knots = (RPM/16.767 + 0.6) * 0.8684
400	21.24			
700	36.77			Full Scale Volt _____
1000	52.31			
1000	52.31			Half Scale Volt _____

Speed Accuracy: R.M. Young (Difference TRUE – ESC  $< 0.4$  kts + 5% TRUE)

RPM	TRUE	ESC	Difference	
	Knots	Knots	TRUE – ESC	0 – 86.84 Knt = 0 – 1 Volt
0	0.0			
500	4.76			Knots = $0.00952 \times \text{RPM}$
2000	19.04			
4000	30.08			
6000	57.12			
9000	85.68			

Speed Linear Regression: Slope = \_\_\_\_\_, Intercept = \_\_\_\_\_, Correlation = \_\_\_\_\_

Comments: \_\_\_\_\_

Calibrated by \_\_\_\_\_ Checked by \_\_\_\_\_

MLD-128 (04/01/94)

Figure T.3.1.1  
Wind Speed Calibration Datasheet

CALIFORNIA AIR RESOURCES BOARD  
CALIBRATION REPORT

To: Michael Spears, Manager  
Special Purpose Monitoring & Data Support

From: Reginald Smith  
Air Pollution Specialist

Log Number: SPM  
Calibration Date: 07/12/94  
Report Date: 07/12/94

IDENTIFICATION

Instrument: R.M. Young Wind Speed Sensor		Site Name: Stockton – Hazelton
Model Number: 05305		Site Number: 39-252
Property Number: SJV 19		Site: ARB
Serial Number: 7868/170205		Location: 1601 East Hazelton
Previous Calibration Log Number: AMCSR 93-356.2		Instrument Property of: ARB
Elevation: 100'	Site Temperature: 25°C	Barometric Pressure: N/A mm Hg

CALIBRATION STANDARDS

Standard	I.D. Number	Certification Date	Certified Value of Factor
R.M. Young Torque Disc (0 to 15 gms-cms)	SPM-1	N/A	N/A
R.M. Young 18810 Selectable Drive (10 to 1000 rpm)	20003895	Factory	N/A

CALIBRATION RESULTS

Component		Wind Speed		
Instrument Range, knots		0 to 86.84		
AS-IS Starting Torque, gm-cms		0.5		
FINAL Starting Torque, gm-cms		N/A		
AS-IS Avg, Speed Difference, knots		-0.04		
FINAL Avg, Speed Difference, knots		N/A		
Best Fit Linear Regression	Slope	0.9991		
	Intercept	0.0746		
	Correlation	0.99999		

Comments: \_\_\_\_\_

Calibrated By Reginald Smith

Checked by \_\_\_\_\_